(1)

(UNCLASSIFIED)

AD ______________

TASK VALIDATION FOR STUDIES ON FRAGMENTED SLEEP AND COGNITIVE EFFICIENCY UNDER STRESS

ANNUAL REPORT

Charles Graham, Ph.D.

June 1981

Supported by

U.S. Army Medical Research and Development Command
Fort Detrick, Frederick, Maryland 21701-5012

Contract No. DAMD17-80-C-0075

Midwest Research Institute
Kansas City, Missouri 64110

Approved for Public Release; Distribution Unlimited

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

(UNCLASSIFIED)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	
2. GOVT ACCESSION NO.	AD-A158 107
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle)	TASK VALIDATION FOR STUDIES ON FRAGMENTED SLEEP AND COGNITIVE EFFICIENCY UNDER STRESS
5. TYPE OF REPORT & PERIOD COVERED	Annual; May 1, 1980 to March 30, 1981
6. PERFORMING ORG. REPORT NUMBER	MRI No. 2007-E
7. AUTHOR(s)	Charles Graham, Ph.D.
8. CONTRACT OR GRANT NUMBER(s)	DAMD17-80-C-0075
9. PERFORMING ORGANIZATION NAME AND ADDRESS	Midwest Research Institute 425 Volker Boulevard Kansas City, MO 64110
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	6277A.3E162777A879.AB.005
11. CONTROLLING OFFICE NAME AND ADDRESS	U.S. Army Medical Research and Development Command Fort Detrick, Frederick, MD 21701-5012
12. REPORT DATE	June 1981
13. NUMBER OF PAGES	21
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	
15. SECURITY CLASS. (of this report)	Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Human performance, information processing, ~~decision making~~, ~~risk~~ taking behavior, computerized performance tasks, fragmented sleep, ~~stress~~ crisis, error analysis.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The goal of this ongoing project is to develop a comprehensive, computer software package that will allow the presentation of a complex performance task, and the evaluation of changes in human information processing, decision making and risk taking behavior under a variety of controlled stress and workload conditions. This report presents our progress to date. The task has been designed and programming is nearing completion. The finished product will be ready for task validation testing within the next 3 months.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(UNCLASSIFIED)

AD ____________________

TASK VALIDATION FOR STUDIES ON FRAGMENTED SLEEP AND COGNITIVE EFFICIENCY UNDER STRESS

ANNUAL REPORT

Charles Graham, Ph.D.

June 1981

Supported by

U.S. Army Medical Research and Development Command
Fort Detrick, Frederick, Maryland 21701-5012

Contract No. DAMD17-80-C-0075

Midwest Research Institute
Kansas City, Missouri 64110

Approved for Public Release; Distribution Unlimited

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

(UNCLASSIFIED)

SUMMARY

The goal of this project is to develop a comprehensive, computer software package that will allow the presentation of a complex performance task, and the evaluation of changes in human information processing, decision making and risk taking behavior under a variety of controlled stress and workload conditions. This report presents a summary of progress to date. The task has been designed, and active programming is nearing completion. The finished product will be ready for task validation testing on human subjects within the next 3 months. A proposal for the conduct of such testing is being submitted simultaneously with this report.

FOREWORD

This Annual Report covers the period from May 1, 1980 to March 31, 1981, and presents a summary of progress to date. The project is still ongoing, and the material presented here should be considered preliminary in nature. The project goal will be attained within the next quarter, and all task parameters and measures finalized during that period. For the protection of human subjects, the investigators have adhered to policies of applicable Federal Law 45CFR46. The work accomplished in this project is a team effort. Members of the project team include: Harvey D. Cohen, Co-Principal Investigator, Dr. Mary R. Cook, Section Head, Biobehavioral Sciences, Dr. Sophia S. Fotopoulos, Director, Life Sciences Department, Jim Phelps, Associate Computer Specialist, and Mary M. Gerkovich, Associate Biostatistician.

TABLE OF CONTENTS

A. Objective

The military technical environment has become increasingly complex and machine-interactive, and personnel who function in this environment face the increased probability that they will be called upon to perform critical cognitive activities under sustained performance or various environmental stress conditions. A clear need exists to develop effective techniques to aid individuals in maintaining cognitive and performance efficiency under such circumstances. The development of effective techniques, however, requires the prior development of research protocols and experimental tasks which focus specifically on those cognitive and performance components most relevant to a high technology environment. Such protocols and tasks must allow the detailed analysis of errors and error paths in information processing, decision making and risk-taking behavior. The goal of the present project is to develop an experimental paradigm, consisting of a complex computerized task and associated performance parameters, which will meet these needs.

B. Background

Previous research in the area of sustained performance has been concerned primarily with the effects of sleep loss in relation to real-world problems involving driver performance, general watch-keeping ability, perceptual-motor skill and alphanumeric manipulation. As a consequence, the experimental tasks and procedures in common use reflect these interests. Subjects typically work for long periods of time at relatively simple and boring tasks. Little performance related reinforcement is provided, and if stress is introduced, this usually occurs in a static fashion by simply requiring that the same tasks be performed simultaneously or under different time constraints. A critical review of the relevant literature indicated that the typical performance tasks used in previous research were not adequate for the purposes of the present project. Such tasks generally were not able to sustain interest and involvement, required relatively low levels of cognitive activity, and neither stress factors nor reinforcement contingencies could be systematically altered. An adequate experimental task should have the following characteristics:

* Task should require subjects to process information, solve problems and make decisions.
* Task parameters should be operationalized and quantified.
* Task should be amenable to continuous performance situations.
* Task should be sufficiently interesting to maintain motivation over long periods of time.
* Task should allow the alteration of performance priorities and difficulty levels.

* Subjects' performance at the task should have meaningful positive and negative consequences.

* Task should allow stress to be introduced in a dynamic fashion.

* Task should be capable of being performed by an individual, a group, or groups in competition.

These characteristics imply that the best approach is to place the subject in a situation where he must continuously use higher-order cognitive functions to perform a complex activity. At the same time the situation should be such that interest is maintained, stress factors can be systematically altered, and multiple cognitive performance parameters can be operationalized and quantified.

The cognitive parameters of major interest are: (a) the ability to assimilate and integrate multi-source, variable-priority information; and (b) the ability to maintain long-term efficiency under the pressures of time, ambiguity and shifting priorities. Finally, the experimental situation of interest is not the typical low-stimulation environment; rather, it is one of sustained crisis, in which individually relevant consequences ride on the outcome of decisions made under ambiguous circumstances.

These considerations led to the decision to create a task patterned after existing futuristic computer war games. The advantages of using this type of basic task activity are (1) performance of the task is almost entirely in terms of information processing, problem solving, and decision making; (2) task activities occur continuously as discrete, repetitive units of time-limited behavior which can be operationalized and quantified; (3) high levels of sustained interest have been demonstrated; and (4) stress factors and reinforcement contingencies can be introduced and altered in a systematic fashion.

C. Progress to Date

During the first quarter, five existing computer war games were identified and located. Detailed information, paper documentation and/or computer disk copies of the source programs for these versions were obtained. Four of the five versions were made operational on our computer system. These versions were compared and evaluated to determine their suitability to serve as a core program to be modified and extended. Details of the internal program architecture, the mathematics involved in program parameter setting, and the logic underlying operator command/control procedures were derived and flow-charted.

The version selected for modification contains a number of versatile modules and command options, and is highly accessible to modification and extension. The software language is FORTRAN IV. This language was selected over BASIC for the following reasons: (1) it has a universal standard syntax in contrast to BASIC which often has a different statement syntax depending on the product company; (2) our FORTRAN IV complies with the American National Standard FORTRAN X 3.9-1966; (3) the execution speed for FORTRAN is faster than BASIC during real-time data acquisition operations, and thus it provides greater precision; (4) FORTRAN programs compile before run time, while BASIC programs are compiled into a machine code at execution time; thus, when using computer memory overlays, FORTRAN programs rarely result in a perceptible time delay; and (5) FORTRAN provides greater stand-alone modularity; for example, variables cannot be passed to subroutines in BASIC.

Project activities then focused on the preparation of a detailed working plan for the modification and extension of software required to present the task. The preparation of this plan was a necessary part of project activity since existing versions of the war game provided no acceptable means to operationally define and set basic task parameters such as difficulty level or duration. Additionally, our review of the various operator command options indicated that several of these options were more "window-dressing" than functional commands. For example, the commander had a choice of using two types of offensive weapons. The program, however, provided no means for him to make a risk or cost/benefit assessment in choosing to use one weapon system over the other. Thus, one aspect of the preliminary plan was concerned with setting into the program procedures for the commander to make such assessments so that the adequacy of his decision-making ability and risk-taking behavior under various conditions can be evaluated. Other parts of the plan were concerned with similar problems in relation to other command options. The basic task plan was then further refined and expanded to include the necessary performance measures, and actual programming of the task began.

Unfortunately, progress during this period was severely hampered. Our computer and laboratory facilities were moved to a new location within the Institute, and the building contractor failed to complete construction on schedule. A 3-month time extension was, therefore, requested and received. Laboratory and computer facilities are now fully operational; and programming of the task, which is described in detail in the next section, will be completed in the near future. The material presented in this Annual Report is therefore preliminary in nature and represents our progress to date. The task will be fully completed by June 1, 1981.

D. Description of the Task

1. Program identification: Strategic and Tactical Assessment Record (STAR): This program was developed by Midwest Research Institute for the U.S. Army Medical Research and Development Command under Contract No. DAMD17-80-C-0075 (Dr.Charles Graham and Harvey D. Cohen, Co-Principal Investigators, James W. Phelps, programmer, Frederick W. Hegge, COTR).

2. Operating environment: The general operating environment consists of any computer system with a FORTRAN IV compiler and real-time clock hardware subroutine library. Necessary peripheral devices include a VT-52 interactive display scope or its equivalent. The specific operating environment used at MRI consists of:

Computer: DEC PDP 11/03 or 11/34 series
Operating system: DEC RT-11 version 3 or later
Program language: DEC FORTRAN IV version 2.0
Hardware peripherals: Programmable real-time clock, flexible or hard disk
Terminal: DECSCOPE VT-52 cursor control codes
Library Calls: Loading and inspection of addresses. Timed interrupt completion routines from programmable clock.

3. Task overview and scenario: A primary problem in past efforts to assess the effects of fatigue and stress on long-term cognitive performance has been the confounding between those effects that are real and those that are due to boredom or lack of performance consequences. The majority of experimental tasks are boring to perform for long periods of time, and most have difficulty sustaining consistent, high levels of operator motivation. STAR has been specifically designed to maintain high motivational and interest levels, while at the same time providing unobtrusive multiple measures of performance.

The task is embedded in the context of a futuristic war where the operator is required to continuously make strategic and tactical decisions in order to accomplish his mission. The operator has at his disposal an array of sophisticated battlefield control systems. These systems are activated through operator interactions with the computer terminal. The results of each command decision are displayed to the operator on the computer graphics scope. The primary measures of performance and decision adequacy are derived from the timing and type of interrogatory, response and action commands issued by the operator during his mission. In essence, STAR presents a highly repetitive experimental performance task which employs a number of traditional measures of decision making and information processing ability. The major difference between STAR and previous tasks lies in the unobtrusiveness of its measures and the context in which the task is embedded.

The operator assumes the role of commander of a Federation cruiser (VENTURE) and is sent repeatedly on missions which vary in difficulty and duration. The task on any particular mission is to locate and destroy a specified number of alien cruisers (Xenoids) within the time limits of that mission.

The successful accomplishment of a mission is dependent on the knowledge and skill of the commander in using the automated battlefield control systems available to him. Available systems include: short- and long-range sensors to help locate the Xenoids and navigate through the galaxy; two types of offensive weapons (phasers and photon torpedoes) for use during attack; defensive energy shields to protect the VENTURE from the effects of attack or collision; impulse engines for movements over short distances and warp engines for long-distance travel; and an on-board computer system which provides information on the extent of damage and the status of various energy system levels, presents a visual long-term memory display of all previous long-range scans requested during a mission, and allows the commander to shift energy resources from his reserve supply to the various systems of his cruiser.

On each mission, the commander is required to balance risks and assess benefits in accomplishing his assigned task. He starts each mission without adequate fuel or armament to complete the mission. These items can be replenished by docking at the Home Universe Base (HUB). The docking procedure incorporates a tracking task. The commander must calculate risk/benefit ratios during the attack situation, in plotting navigation courses, and when using the defensive shields which drain the energy supply. In addition, the commander has only a finite period of time to complete his mission. Every movement of VENTURE from one point to another in the universe subtracts time from the allowable total for the mission and requires energy. Thus, the commander cannot simply travel blindly over the galaxy; rather, he must develop an efficient search strategy that balances mission goals against energy and armament supplies and time. Similarly, faulty navigation resulting in a collision will make certain systems of the VENTURE inoperable for periods of time. The commander then has to make decisions between effecting quick repairs, which cost mission time in proportion to the type and extent of damage, against proceeding with the mission and not using the damaged systems until normal repairs are completed some time later.

The commander is also faced with additional hazards. Present in the galaxy during each mission are variable numbers of more sophisticated enemy vessels. Phantom Xenoids are not detectable by VENTURE scanners. They appear suddenly and unexpectedly, and unless the commander takes immediate defense action can inflect serious damage. Thus, the commander must exercise continuous vigilance to avoid damage to VENTURE. A second type of more sophisticated enemy vessel is the Super Xenoid. This type of enemy is detectable by VENTURE scanners; however, it is camouflaged so that it appears to be a typical Xenoid cruiser. Only when the commander enters a quadrant containing a Super Xenoid does he become aware of its presence. Super Xenoids have the technical ability to drain the energy systems of the VENTURE at a steady rate, and begin to do so as soon as VENTURE enters the quadrant. The commander must then decide how to destroy the Super Xenoid with minimal energy loss.

The commander begins his mission by flying a shuttle craft to HUB (standardized tracking task) to take command of his vessel. VENTURE then enters the galaxy at quadrant 1,1 (the universe is divided into 64 quadrants arranged as an 8 x 8 grid, and each quadrant is in turn further divided into 64 sectors on the same basis). The location of Xenoids and stars is unknown to the commander. The commander issues movement commands via the terminal, and the VENTURE travels from quadrant to quadrant searching for and destroying the Xenoids. The commander uses his short-range scans to examine the contents of the quadrant in which VENTURE is presently located. If Xenoids are present, he adjusts his shields accordingly and attacks using either his torpedoes or phasers. The results of these actions are continuously displayed on the graphics scope. VENTURE can be destroyed if the Xenoids break the energy shields of the crusier. Once the action is completed within a particular quadrant, the commander resumes his search. Generally, he requests a long-range scan which will reveal the number of Xenoids and stars within the surrounding eight quadrants, but not their exact locations. He then plots a navigation course, checks for possible collisions, and issues a movement command. Once at the desired new location, he attacks the

Xenoids present. At other times, the Commander will move to a location in the galaxy which is outside the previous range of his long-range sensor and begin a search of the new area.

Prior to any movement of the VENTURE, the commander must use the terminal to enter into the mission log the purpose of the movement (search, attack, evade) and the desired destination (e.g., quadrant 4,6). At the beginning and end of each mission, the commander makes a status report. During the mission, each time the commander wishes to return to the HUB he must state the specific reason and provide a status report. Thus, the use of VENTURE battlefield control systems incorporates unobtrusive measures of the commander's intent and reasons for actions. This feature of the program allows careful analysis of errors and sequences of activities that led to error.

The commander continues making between-quadrant strategy decisions and within-quadrant tactical decisions until the mission goal is accomplished or the mission duration is met. The commander is then sent on another mission, and the above sequence repeats.

4. Playing elements: There are six playing elements in the task: VENTURE cruisers, Xenoids, Phantom Xenoids, Super Xenoids, the Home Universe Base (HUB), and stars.

a. Venture class cruiser: There is only one VENTURE cruiser per mission, and the operator is in command of this cruiser. The VENTURE class consists of cruisers designated 1 to 15. Cruisers 1 to 10 are battle cruisers, and cruisers 11 to 15 are training cruisers. Initially, the operator is assigned to command VENTURE 15. If his missions are successful, he moves up the ranks, until he commands VENTURE I. If his mission fails, he is demoted one rank and commands the cruiser with the next lowest number designation. The symbol used to identify a VENTURE cruiser on the display scope is a "V".

b. Xenoid: This element is pronounced zénoid, and it is the enemy the commander must seek out and destroy during each mission. The graphics symbol used to identify a Xenoid is the letter "X". Xenoids are distributed throughout the universe such that some quadrants contain no Xenoids and other quadrants contain from one to three Xenoid cruisers. These enemy cruisers do not have the capability to fire photon torpedoes at VENTURE cruisers. They can fire phasers, however. Phaser fire is directed at the VENTURE if it moves within a quadrant, if it attacks but does not destroy a Xenoid, or if it attacks any Xenoid in a quadrant containing two or more Xenoids. Xenoids never miss. The amount of damage inflicted by their phasers depends upon the commander's deployment of shield energy. Xenoid phaser fire must be line-of-sight, a commander can, therefore, avoid damage by finding a favorable position from which to begin his attack.

c. Phantom Xenoids: These are rare, ultra-sophisticated Xenoid cruisers. Through some, as yet, unknown technology, Phantoms have the following capabilities:

1. They can remain unseen and undetected until they choose to appear; they appear only in quadrants occupied by other Xenoids. Probability of occurrence is under experimenter control.

2. They appear suddenly, but only when VENTURE has attacked another Xenoid.

3. The VENTURE commander can defend himself against attack if he can activate a special Phantom defense shield within 4 sec after the Phantom appears.

4. The Phantom will sense the activation of the special shield in this time period and disappear to attack again at another time.

5. If the special shields are not activated in time, the VENTURE will be fired on once and severely damaged. The Phantom will then break off the attack and disappear.

The short range sensor scan of the VENTURE cruisers has been equipped with a special device to immediately detect the presence of a Phantom. The symbol used to communicate this information to the Commander is the letter "P".

d. Super Xenoids: Super Xenoid vessels have the same fighting characteristics as the regular Xenoids. In addition, they deplete energy from the VENTURE's reserve stores at a rate of 25 units/sec from the time the VENTURE enters the quadrant until either the Super Xenoid is destroyed, or the VENTURE leaves the quadrant. Super Xenoids are identified on the display by the symbol XXX. Super Xenoids are identifiable in long-range scans only as Xenoids; their super properties become apparent to the commander only when he enters a quadrant containing a Super Xenoid.

e. Home Universe Base (HUB): There is one HUB which orbits outside the galaxy and is responsible for repairs, supplies and mission control. In order to reach HUB, the commander must request docking, specify the reason for the request, and track through a moving energy path in order to reach his destination. The standard tracking task required for docking is 2 min in duration. If the commander fails to follow the energy path (makes tracking errors) additional time penalties are added.

f. Stars: This playing element is identified by an asterisk (*). Stars are numerous, and are distributed such that most quadrants contain at least one, and some quadrants contain up to eight stars. Because of their size and their orbits, stars fully occupy the sectors in which they are located. This means the commander must navigate around stars and he cannot shoot his photon torpedoes through stars. Faulty navigation resulting in collision with a star will damage VENTURE, and firing a torpedo at a star will not destroy it, it will only waste one torpedo and the energy required to fire that torpedo.

5. Information displays: During the mission, the operator is seated at the computer terminal. He commands VENTURE through appropriate

use of the terminal keyboard, and observes the results of his actions on the visual display. The display screen provides four discrete categories of information.

a. Strategic and tactical scan information: The left side of the visual display presents an 8 x 8 grid. This grid is permanently displayed during all segments of the mission, except when the commander goes into docking mode. Depending on the commands issued by the operator, the grid display is used to present three distinct types of information.

(1) Short-range scan: On operator command the 8 x 8 grid presents the location of all objects in the 64 sectors of the quadrant in which VENTURE is presently located. VENTURE is represented by the letter V, Xenoids by the letter X, Super Xenoids by the symbol XXX, Phantom Xenoids by the letter P, and Stars by an asterisk.

(2) Long-range scans: When the operator issues a long-range scan command, all shortrange scan information is erased from the screen. The 8 x 8 grid is then used to represent the 64 quadrants of the galaxy. The long-range scan then presents information on the contents of the eight quadrants immediately surrounding the position of VENTURE. This information is presented in the form of 2-digit numbers in which the tens position indicate the number of Xenoids and the units position indicate the number of stars. The location of Xenoids and stars within each quadrant is not indicated by the scan.

(3) Scan history: The program holds in memory all information revealed in previous long-range scans called by the operator. When the operator calls for a scan history, the previous contents of the 8 x 8 grid are erased and replaced by a summation of all information previously presented in long-range scans.

b. Command and text information: The command and text area occupies the top right part of the display screen. Commands are accepted whenever the "COMMAND ?" prompt is visible. After a command is entered, the appropriate question and answer text occupies the command area. Following the last answer, the command text area goes blank while the requested action occurs. The command prompt then reappears. Once a command is entered, the operator cannot make another command until the requested command has been executed unless he enters a special "cancel" command. This procedure allows monitoring of command entry errors which are recognized by the operator prior to complete execution of the command.

c. Ship status information: Information about the status of the VENTURE is presented in the middle right portion of the screen. Continuously updated information is presented on current levels of energy available in seven crucial systems (energy to fire torpedoes, energy to fire phasers, shield energy, fuel, life support, repair energy, and reserve energy), number of photon torpedoes remaining, and status of damage, if any, in the above systems.

d. Mission status information: Mission status information is presented in the lower right section of the screen. This information includes mission time remaining, present location of VENTURE, and number of Xenoids remaining.

The information display described above is presented during all segments of the game other than the docking segment. When the operator keys in the dock command, the display is erased from the screen and a moving narrow bank appears on the screen. The curser represents the VENTURE, and is located within this band. The operator's task is to use position control keys on the terminal to keep the VENTURE within this narrow bank as it weaves up the screen. When the tracking task is completed (VENTURE arrives safely at HUB), the mission time clock is updated and displayed, and the screen is used to present questions relevant to measures of long-term and recent memory and to measures of physical and psychological status.

6. Operator commands: The operator uses the terminal to make 10 distinct commands.

a. Navigation: The operator calls the navigation sequence by depressing a specific key. He must then indicate the intent of his activity (Search, Attack, Evade) and his desired destination (x, y coordinates). He must then enter his course and warp factor. Course is determined relative to units of the face of a clock. For example, in order to move to the right, the operator would enter a course of "3". The warp factor determines the distance over which the VENTURE will move. Warp factors of .1 to .7 move the VENTURE the corresponding number of sectors, while warp factors of 1 to 7 move the ship the corresponding number of quadrants. When the command series is complete, the VENTURE is seen to move out of the quadrant. The difference between desired destination and actual destination is retained in memory as one of the performance measures.

b. Short-range scan: This is a single operation command activated by depressing a specific key on the keyboard. It reveals the location of all objects in the present quadrant. Unlike most games of this type, objects in the scan are seen to move and to blow up. Thus, on a movement command VENTURE moves along the designated course, the track of a torpedo is displayed, and enemy vessels hit by either a torpedo or a phaser can be seen to disintegrate.

c. Long-range scan: This command causes the contents of the present quadrant and the eight surrounding quadrants to be displayed as 2-digit numbers.

d. Scan history: This command causes the contents of all previous long-range scans to be displayed simultaneously.

e. Photon torpedo control: This command is activated by depressing a specific key on the terminal. The operator must then set the course of the torpedo using the clock face units previously described. The difference between the course set by the operator and the optimal course is retained in memory as one of the performance measures.

f. Phaser control: Unlike photon torpedoes, phasers automatically lock-on to all enemy vessels in the quadrant. The operator is required to calculate and enter the payload necessary to destroy these targets. The difference between payload set and optimal payload is retained in memory.

g. Emergency Phantom Xenoid shield: By keying this command within 4 sec after the appearance of a Phantom Xenoid, the operator can avoid damage to the VENTURE. Response time is retained in memory as a performance measure.

h. Resource control: Keying this command allows the operator to transfer energy from the reserve supply to any of the ship's systems. The operator must specify the units of energy to be transferred, and the specific system (e.g., shields, phasers).

i. Docking: This command is only used when the operator wishes to travel to the HUB. The operator must enter the reason he is requesting docking. Specified reasons are shuttle (beginning and end of mission) resupply and repair. If either of the latter two are designated, the operator must further specify the system with the highest priority. The tracking task is an integral part of the docking procedure.

j. Cancel: This command allows the operator to cancel a command which has been entered but not yet executed. The number of cancel commands is maintained in memory.

7. Parameters under experimental control: Prior to the beginning of each mission, the experimenter can specify:

* The number of Xenoids in the galaxy;

* The distribution pattern of the Xenoids; (proportion of quadrants containing 0, 1, 2 or 3 Xenoids);

* The percentage of Xenoids designated as Super Xenoids (0 to 33%);

* The rate of appearance of Phantom Xenoids;

* Whether or not the mission is under time pressure. In time pressure missions, reserve energy is depleted at a fixed rate if the operator does not issue a command within the specified time limits (10-30 sec).

* Mission duration.

By systematically manipulating and combining the above variables, the parameters of task difficulty, workload and consequences can be altered. Both the dimensions of "time" and "energy" are used for this purpose. Initially, the player is assigned a certain amount of energy and mission time to destroy all the enemy vessels. Systems that require energy during play include:

Torpedoes, Phasers, Shields, Fuel for movement, Life Support, and Repairing damage. The player also has a large amount of reserve energy that can be transferred to those systems during the game via the Resource Command. Returning to the HUB via the dock command replenishes the energy levels, at the cost of docking time. The sense of time is real in the game, as the mission clock steadily displays the amount of time left in the mission. Additionally, in pressure missions the commander must operate against time, or suffer energy loss. Thus, the experimenter can introduce a realistic situation in which the operator is competing against time and energy (or fuel), and supplies must be monitored and maintained in order to seek and destroy the enemy.

8. Performance measures: STAR has been designed as a complex cognitive performance task. It is anticipated that it will be used to examine higher order functioning under long-term continuous performance conditions as well as to assess effects of various types of environmental stressors. Since the research paradigm is new, a number of measurement parameters have been included in the design of the task. Some of these measures will undoubtedly prove to be more useful under specific conditions than others. All measures are obtained either by the subject keying in responses to information requests that appear on the video screen when the VENTURE is docked at the HUB, or from mission information stored in the computer as the task is performed.

a. Overall efficiency: Number of movement commands per Xenoid destroyed.

b. Search efficiency

(1) Number of long range scans containing redundant quadrant information.

(2) Number of long range scans.

(3) Number of redundant quadrants in long range scans.

(4) Number of entries into quadrants that never contained Xenoids.

c. Attack efficiency

(1) Number of torpedo hits.

(2) Number of torpedo firings.

(3) Number of torpedo hits divided by number of torpedoes fired times 100.

(4) Number of successful phaser attacks.

(5) Number of phaser attacks.

(6) Number of successful phaser attacks divided by number of attacks times 100.

(7) Number of Xenoids destroyed divided by number of attacks.

(8) Time from entry divided by number of Xenoids in quadrant until all quadrant Xenoids destroyed.

d. Attack problem-solving: Data at each weapon firing:

(1) Number of units of energy required to destroy all Xenoids at present location with phasers and with torpedoes.

(2) System actually used: Number of units of energy used with phasers, accuracy of torpedo course.

(3) Number of units of energy available in seven systems.

Data for each quadrant containing Xenoids:

(1) Number of units of energy required at each location.

(2) Number of units of energy used to destroy Xenoids.

(3) Number and types of Xenoids present (difficulty factor on each quadrant).

(4) Number of correct weapon choices divided by number of quadrants containing Xenoids.

e. Navigation errors

(1) Collisions.

(2) Intended destination direction and warp factor.

(3) Keyed in direction and warp factor.

(4) Comparison of 2 and 3 above.

f. Risk taking behavior

(1) Energy levels when returning for resupply.

(2) Energy levels when energy transferred into system.

(3) Shield energy levels during combat and noncombat conditions.

(4) Amount of hits taken by Venture.

(5) Amount of damage to Venture.

g. Response times

(1) Number of phantoms presented.

(2) Number of phantoms missed.

(3) Mean reaction time computed over all phantoms perceived.

h. Data from dockings

(1) Reason for docking: Shuttle
Resupply
Repair
Highest priority system

(2) Tracking performance (percent time on target and root mean square error).

(3) Recent and long-term memory items.

Report:

Where did you come from?
Mission time remaining.
How many Xenoids remain?
How many super Xenoids have you encountered?
How many phantom Xenoids have you encountered?
How many torpedoes do you have?
How much reserve energy do you have?
Are any of the Venture's systems damaged? If yes, specify.

(4) Physical/psychological status report.

1-10 Scales of: Physical activation/deactivation
Levels of perceived stress
Motivation
Confidence
Performance efficiency
Workload
Need for sleep/rest

i. Perceptual accuracy: Sum of $(\text{course set} - \text{optimal course})^2$ divided by number of torpedoes fired.

j. <u>General errors</u>

(1) Number of times operator uses erase key.

(2) Number of times operator uses "cancel" button.

(3) Number of attempts to use damaged equipment.

<u>DISTRIBUTION LIST</u>

Director
Walter Reed Army Institute of Research
ATTN: SGRD-UWZ-AG
Walter Reed Army Medical Center
Washington, DC 20012 (12 copies)

Commander
U.S. Army Medical Researh and
Development Command
ATTN: SGRD-RMS
Fort Detrick
Frederick, MD 21701 (4 copies)

Administrator
Defense Technical Information
Center
ATTN: DTIC-DDA
Cameron Station
Alexandria, VA 22314
(12 copies)

Commandant
Academy of Health Sciences
U.S. Army
ATTN: AHS-CDM
Fort Sam Houston, TX 78234
(1 copy)

Dean, School of Medicine
Uniformed Services University
of Health Sciences
4301 Jones Bridge Road
Bethesda, MD 20014
(1 copy)